FuelCell Energy

World Leader in Ultra-Clean Power

Fuel Cell Power Plants Renewable and Waste Fuels

DOE-DOD Workshop

Washington, DC.

January 13, 2011

reliable, efficient, ultra-clean

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
13 JAN 2011		**00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Fuel Cell Power Plants Renewable and Waste Fuels	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **FuelCell Energy, Inc,3 Great Pasture Rd,Danbury,CT,06813**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
presented at the DOE-DOD Waste-to-Energy using Fuel Cells Workshop held Jan. 13, 2011 in Washington DC. U.S. Government or Federal Rights License

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**23**	

FuelCell Energy, Inc.

- Premier developer of stationary fuel cell technology — founded in 1969
- Over 50 installations in North America, Europe, and Asia
- Industrial, commercial, utility products
- 300 KW to 50 MW and beyond

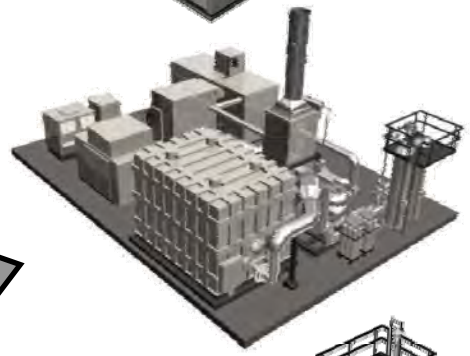
Product Line Based on Stack Building Block

Cell Package and Stack

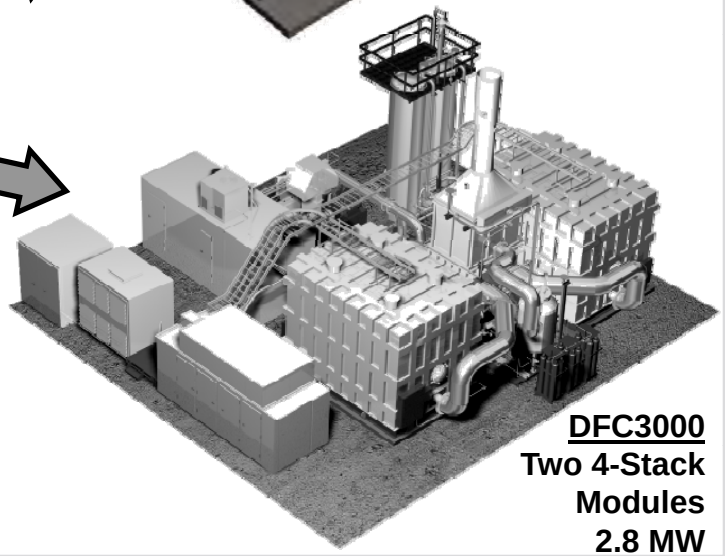
Single-Stack Module

Four-Stack Module

DFC300
Single Module Powerplant
300 kW



DFC1500
One 4-Stack Module
1.4 MW



DFC3000
Two 4-Stack Modules
2.8 MW

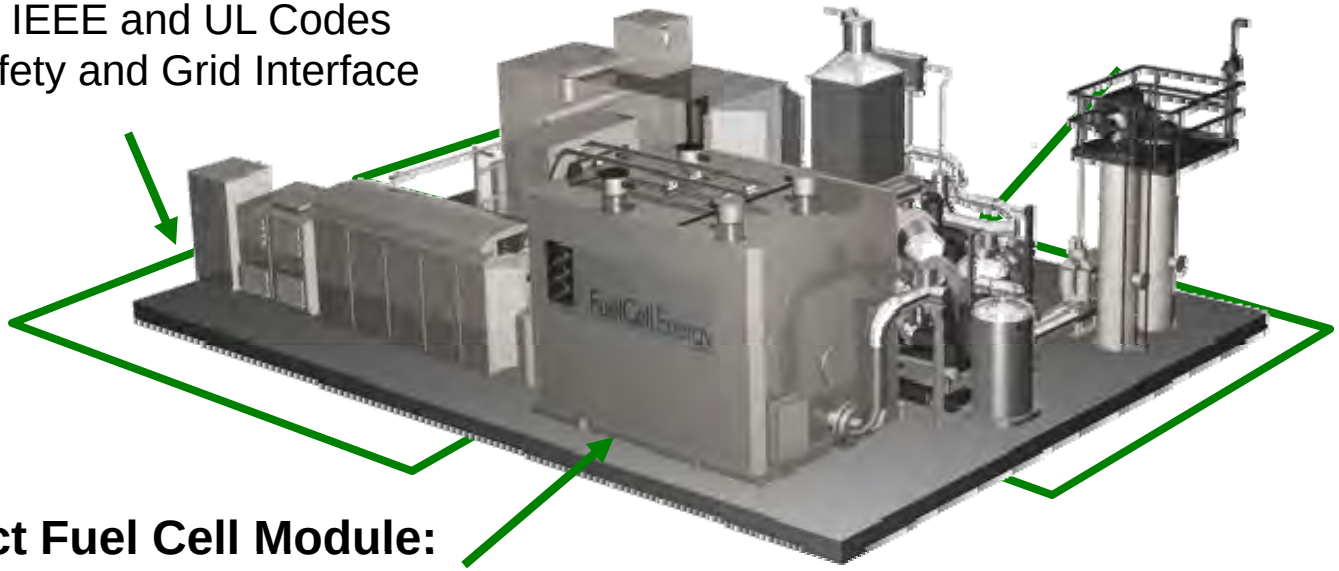
DFC1500 Powerplant Subsystems

Electrical Balance Of Plant (EBOP):

- Converts DC power to grid quality AC power
- Meets IEEE and UL Codes for Safety and Grid Interface

Mechanical Balance Of Plant (MBOP):

- Water and Fuel flow cleanup and preheat
- Air supply, startup heater



Direct Fuel Cell Module:
4-stack Module

Applications

- **On-site self generation of combined heat and power**
  - Clean Power with natural gas fuel
  - Renewable Power with biofuels
- **Grid connected power generation**
  - High Efficiency Grid support
  - Renewable Portfolio Standards

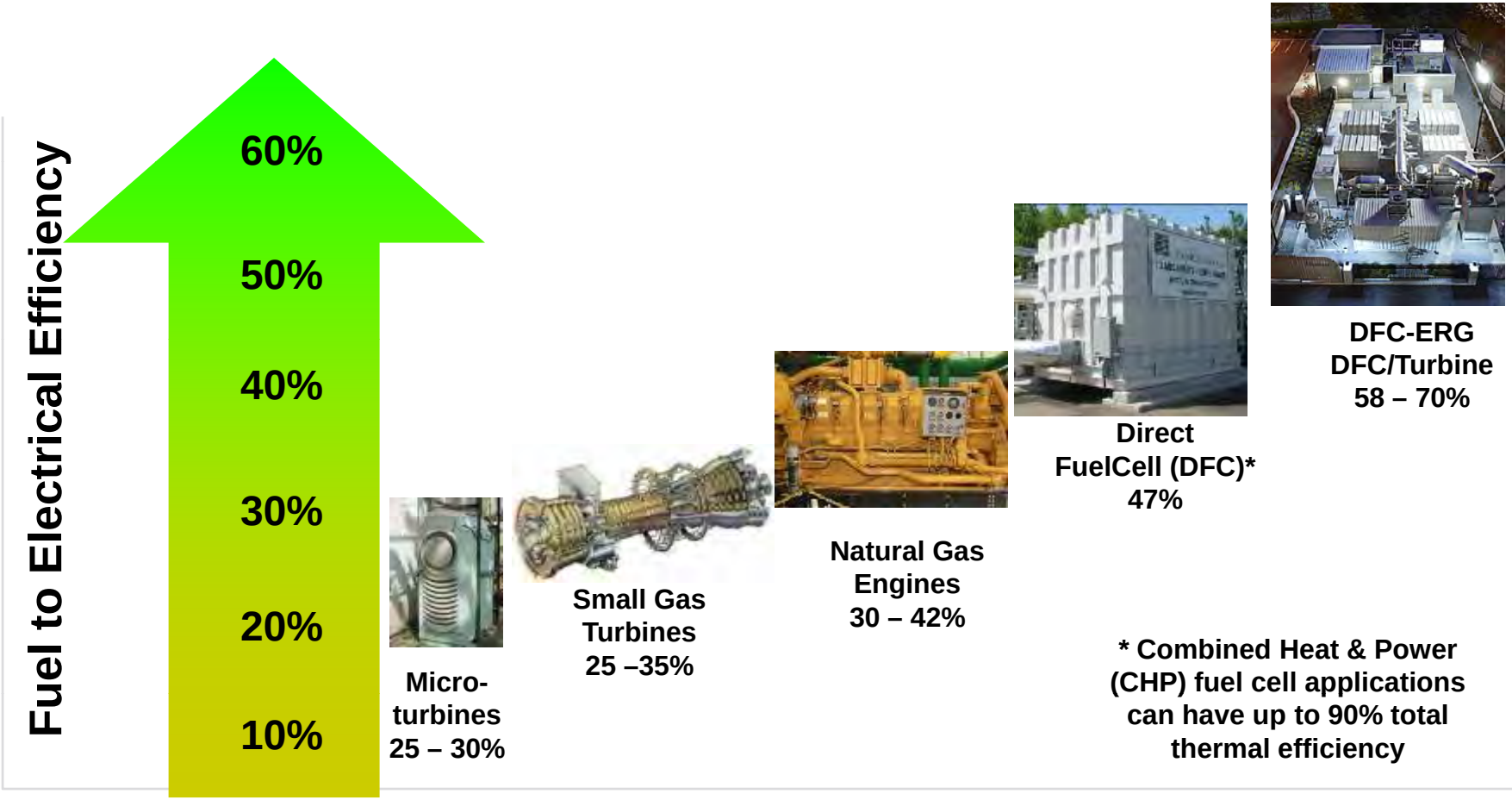
Fuels Resources for DFC

- Natural Gas and LNG
- Propane
- Biogas (by Anaerobic Digestion)
  - Municipal Waste Water Treatment
  - Brewery
  - Food and Animal Waste
- Biogasifier derived Fuels

FuelCell Energy

Comparative Electrical Efficiency

DFC power plants offer the high efficiency



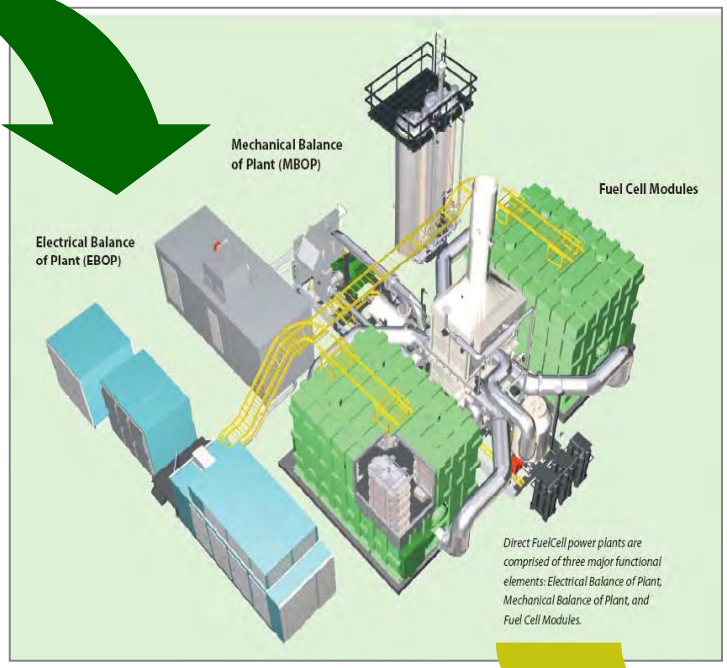
*** Combined Heat & Power (CHP) fuel cell applications can have up to 90% total thermal efficiency**

FuelCell Energy

Fuels Diversity and Efficiency

FUEL RESOURCES

- NATURAL GAS
- PROPANE
- ETHANOL
- WASTE METHANE
- BIOGAS
- COAL GAS



INTEGRATED SYSTEMS IMPROVE EFFICIENCY

- DFC – (47%)
- DFC – CHP (60-80%)
- DFC – ERG (55-60%)
- DFC/T – (55-60%)
- DFC H2 (50-60%)

Diversity of Fuels plus High Efficiency – High Sustainability

FuelCell Energy

Ultra Low Emissions

	NOX (lb/MWh)	SOX (lb/MWh)	PM-10 (lb/MWh)	CO2 (lb/MWh)
Average US Grid	3.43	7.9	0.19	1,408
Average US Fossil Fuel Plant	5.06	11.6	0.27	2,031
Microturbine (60 kW)	0.44	0.008	.09	1,596
Small Gas Turbine (250 kW)	1.15	0.008	.08	1,494
DFC Fuel Cell 47% efficiency	**0.01**	**0.0001**	**.00002**	**980**
DFC Fuel Cell – CHP 80% efficiency	**0.006**	**0.00006**	**.00001**	**552**

Source for non-DFC data: "Model Regulations For The Output Of Specified Air Emissions From Smallerscale Electric Generation Resources Model Rule and Supporting Documentation", October 15, 2002; The Regulatory Assistance Project report to NREL

DFC Advantages for Biogas

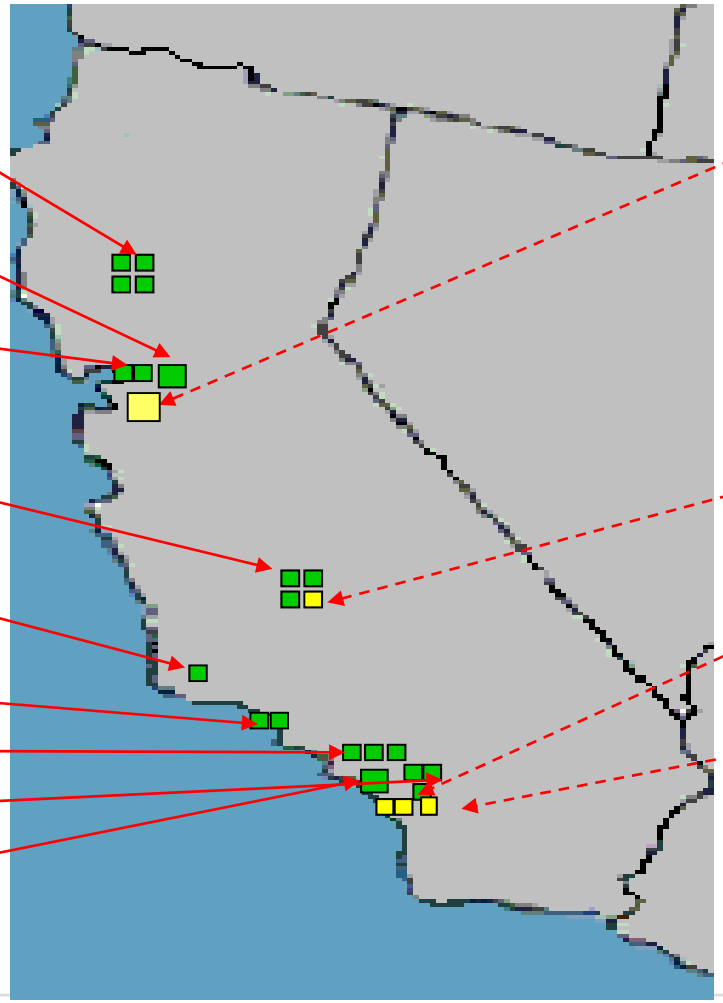
- **More power for given amount of biogas**: Higher efficiency than any other generation at typical digester facility sizes
- **Good heat to power ratio for digester support:** Fuel cell makes enough heat to support digester operation
- **Avoids generation of NO_X and other pollutants** from flare or from other generation technologies

FuelCell Energy

Typical Fuels Composition

Composition	Natural Gas	Biogases			
		Waste Water	Food Waste	Animal Waste	Landfill
Methane (Vol%)	80-100	~50-60	~50-70	45-60	40-55
Carbon Dioxide (Vol%)	<3	30-40	25-45	35-50	35-50
Nitrogen (Vol%)	<3	<4	<4	<4	<20
Oxygen (Vol%)	<0.2	<1	<1	<1	<2
H_2S, ppm	<0.1	<400	<10000	<300	<200
Non-H_2S Sulfur, ppm	<10	<1	<1000	<30	<30
Halogens, ppm	<0.1	<0.2	<0.2	<0.2	<100
Moisture, %	<0.02	~3	~3	~3	~3

Bio-gas Plants in North America



SIERRA NEVADA BREWING COMPANY

TURLOCK IRRIGATION DISTRICT

DUBLIN SAN RAMON RECLAMATION DISTRICT

TULARE WWTP

SANTA BARBARA

GILLS ONIONS

RIALTO WWTP

RIVERSIDE WWTP

EASTERN MUNICIPAL WATER DISTRICT

OLIVERA EGG RANCH

TULARE WWTP

EASTERN MUNICIPAL WATER DISTRICT

Orange County Sanitation District

Tulare CA Wastewater Treatment Plant

- 3 DFC300 Units operating on ADG, provide ~ half of facility load
- 94% Availability from Jan 2008 through Aug 2010
- Recently ordered fourth unit

FuelCell Energy

4 DFC300 Plants
Sierra Nevada Brewery, California

Site With Power Generation in Excess of ADG Supply

First Site with Automated Fuel Blending

Turlock Irrigation District Waste Water Treatment Facility, Turlock, CA

Gills Onion Food Processing Facility, Oxnard, CA

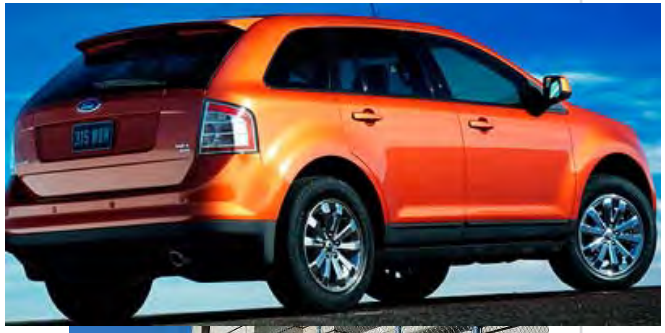
Eastern Municipal Water District Waste Water Treatment Facility, Moreno Valley, CA

VOC Solvent Fuel.

Ford Motor Company, Ontario Assembly

- Challenge:
  - Cost-effectively dispose of VOC*
  - Reduce emissions in paint operations
- Solution:
  - 300 kW Ultra-Clean 24/7 reliable power running on VOC
- Results:

  Low-cost, low-emissions electricity
  - VOC disposal cost cut in half over ten years



* Volatile Organic Compounds

DFC-ERG High Efficiency Application

- DFC-ERG designed for pipeline letdown operations
  - Byproduct heat warms gas to prevent freezing
  - Energy from pressure letdown fed to turbine
  - Combined electricity delivered to the grid
- Improved economics and lower CO2 emissions
- 2.2MW Toronto plant demonstrating technology and validating$_{value}$ proposition
  - Efficiency greater than 70%

2.2 MW DFC-ERG in Toronto

FuelCell Energy

Co-Production of Renewable Hydrogen Orange County, CA

Orange County Sanitation District (OCSD)

Renewable H_2 Filling Station

ADG fueled DFC-H2® Production Unit

Energy Efficiency & Renewable Energy

Southern California Gas Company

California Environmental Protection Agency AIR RESOURCES BOARD

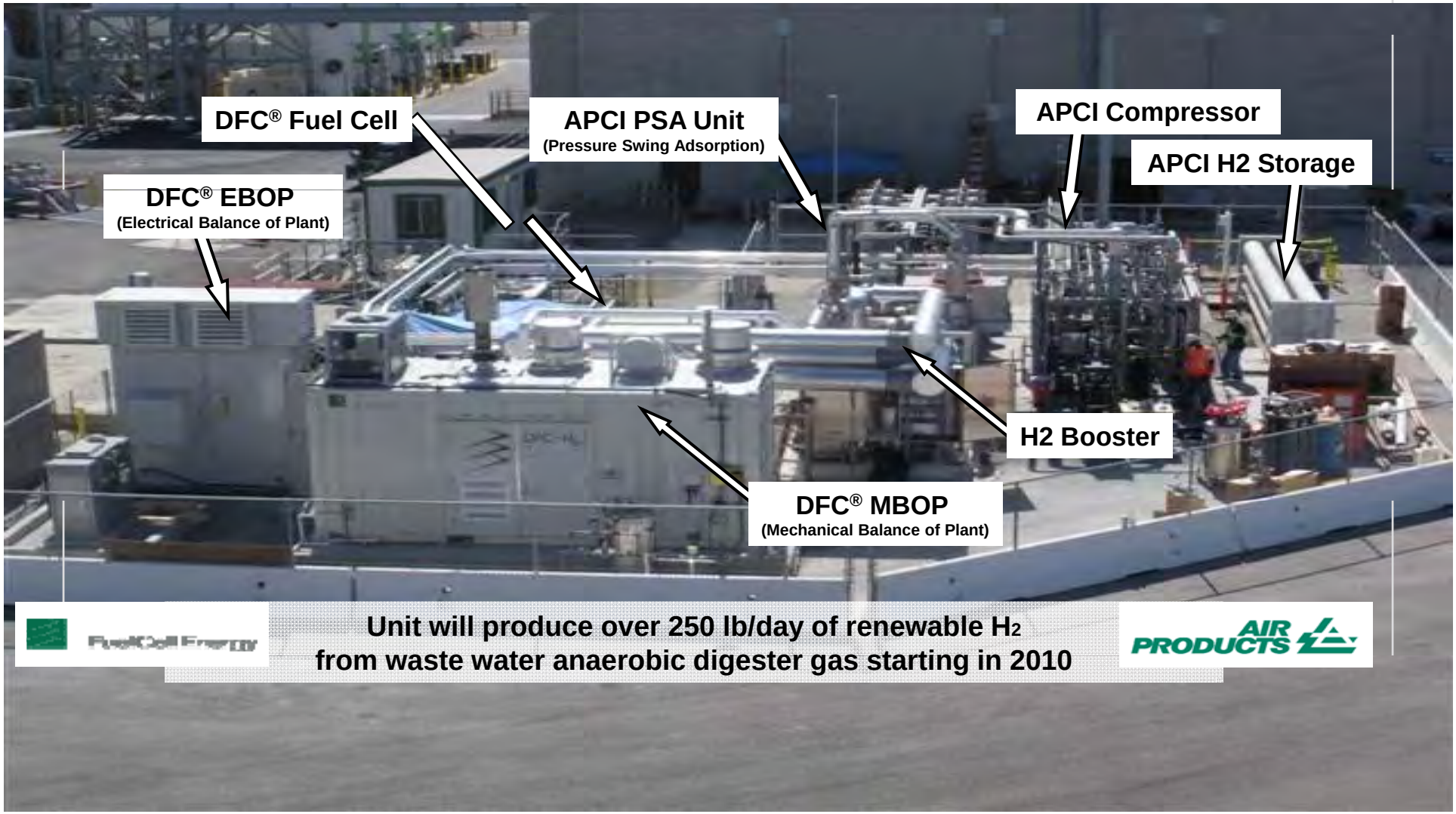
University of California - Irvine

AIR PRODUCTS

FuelCell Energy

Co-Production of Renewable Hydrogen
Orange County, CA

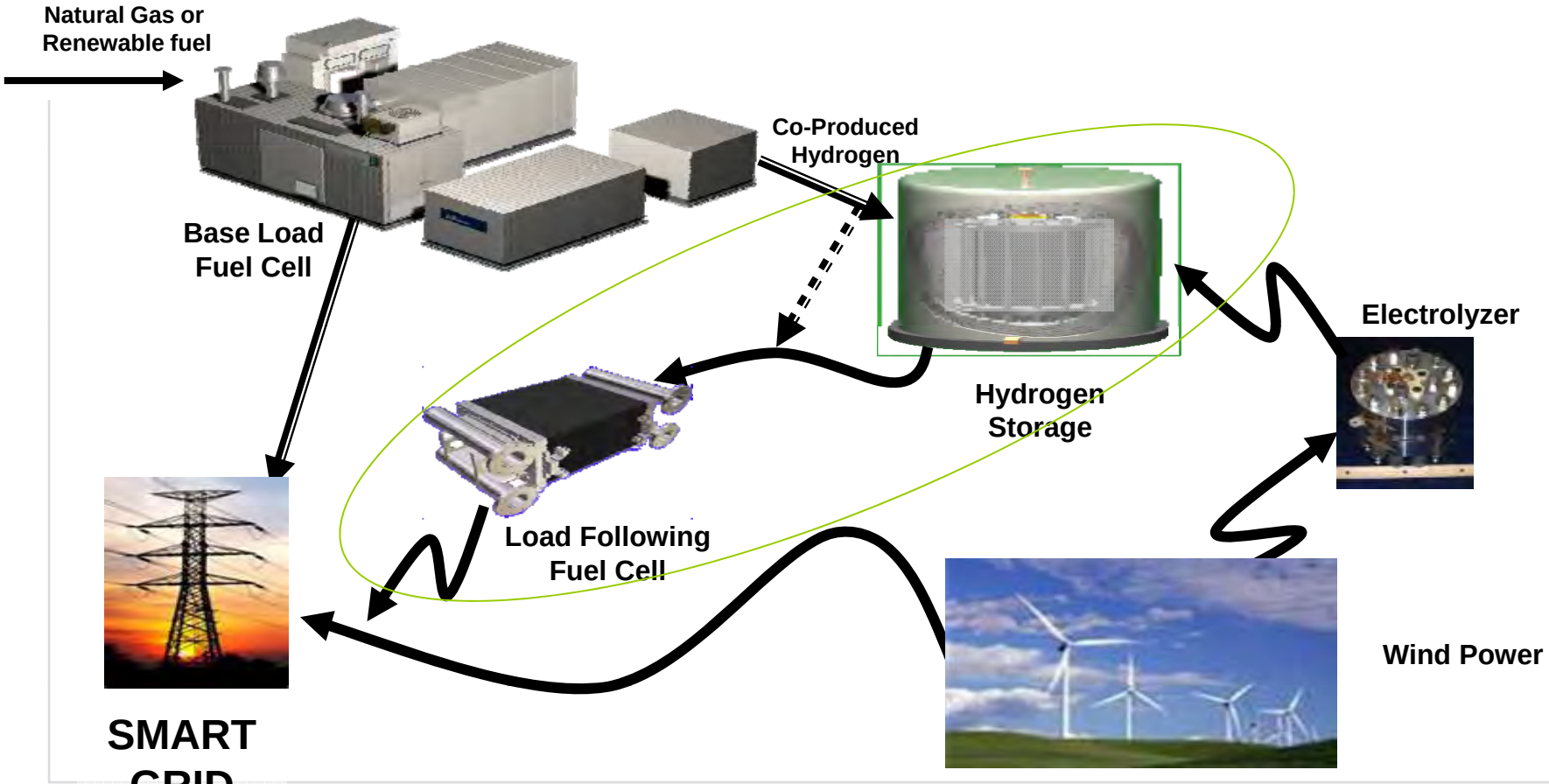
First DFC-H_2® Unit Installation



FuelCell Energy

Smart Grid Integration
Power, Fuel and Energy Storage

DFC-H2® Peaker - Compliments Smart Grid



FuelCell Energy

Co-Production Capacity of DFC-H2® Power Plants

	DFC300®	DFC1500®	DFC3000®
			
Co-product			
Power, kW	250	1,000	2,000
Hydrogen, kg/day	125	500	1,000
Heat, mmBtu/hr	0.5	2.0	4.0
Peaker Capacity			
Peak Power (8 hrs/day), kw	500	2,000	4,000
Refueling Capacity			
Fuel Cell Cars, 0.5 kg/day	300	1,200	2,400